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Effect of Propofol total Intravenous Anaesthesia and Propofol-Isoflurane Anaesthesia on Maternal Recovery and Neonatal Viability Following Caesarean Section in Bitches

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A B S T R A C T

Canine dystocia is one of the most common reproductive emergencies encountered in veterinary obstetrics and is associated with significant maternal and neonatal morbidity and mortality. Emergency caesarean section is often required when medical management fails or fetal compromise is evident. The choice of anaesthetic protocol plays a crucial role in ensuring maternal safety while minimizing neonatal depression, as most anaesthetic agents readily cross the placental barrier and may adversely affect neonatal cardiopulmonary adaptation. This study was undertaken to compare the effects of total intravenous anaesthesia (TIVA) using propofol with propofol induction followed by isoflurane maintenance in bitches undergoing emergency caesarean section for dystocia. Maternal physiological parameters, intraoperative and postoperative recovery, neonatal viability, and early maternal performance were evaluated to determine the most appropriate anaesthetic protocol for clinical practice. Neonatal outcomes were assessed using the modified APGAR scoring system and umbilical blood lactate concentration as objective indicators of neonatal adaptation and metabolic stress. Additional parameters including neonatal body weight, postoperative maternal appetite, onset of lactation, and early puppy survival were also recorded. Comparative evaluation of both anaesthetic protocols demonstrated differences in maternal recovery characteristics and neonatal vitality attributable to the pharmacological properties of the anaesthetic agents. While propofol provided rapid induction and satisfactory surgical anaesthesia, maintenance with isoflurane facilitated superior control of anaesthetic depth, faster postoperative recovery, and reduced fetal anaesthetic exposure, contributing to improved neonatal adaptation. The combined use of clinical assessment and biochemical markers enabled a comprehensive evaluation of neonatal well-being immediately after delivery. The findings suggest that propofol induction followed by isoflurane maintenance offers a more balanced anaesthetic approach by providing adequate maternal anaesthesia while enhancing neonatal viability and postoperative maternal recovery. This study contributes clinically relevant evidence for optimizing anaesthetic management during emergency caesarean section in bitches and supports evidence-based decision-making to improve both maternal and neonatal outcomes in veterinary reproductive practice.

Introduction

The domestic dog (*Canis lupus familiaris*) has become one of the most valued companion animals worldwide, resulting in a growing demand for advanced veterinary reproductive and obstetrical care. Improvements in breeding practices, increased awareness among pet owners and the popularity of pedigree dogs have contributed to a rise in assisted reproductive procedures and obstetrical interventions. Despite advances in reproductive management, dystocia remains one of the most common obstetrical emergencies in bitches and frequently necessitates emergency caesarean section to preserve the life of both the dam and the puppies. Dystocia may result from maternal factors such as primary uterine inertia, inadequate pelvic dimensions or abnormalities of the birth canal, as well as foetal factors including malpresentation, malposition, foetal oversize and congenital anomalies. Delayed intervention may lead to foetal hypoxia, neonatal depression, maternal exhaustion and increased perinatal mortality.

Successful management of canine dystocia depends on early diagnosis, appropriate obstetrical intervention and selection of a suitable anaesthetic protocol. Caesarean section is considered the treatment of choice when medical management fails or when maternal or foetal compromise is evident. However, anaesthetic management during canine caesarean section remains challenging because the ideal protocol should provide rapid induction, adequate surgical anaesthesia, effective muscle relaxation and smooth recovery while producing minimal cardiovascular and respiratory depression in both the dam and the neonates. Most anaesthetic agents readily cross the placental barrier, and prolonged exposure before delivery may adversely affect neonatal physiological adaptation immediately after birth. Therefore, optimisation of anaesthetic techniques is essential to improve neonatal survival and postoperative maternal recovery.

Propofol is one of the most frequently used intravenous anaesthetic agents in small animal practice because of its rapid onset of action, short duration and predictable recovery. It produces satisfactory induction and allows rapid endotracheal intubation with minimal accumulation following repeated administration. Propofol may also be administered as total intravenous anaesthesia (TIVA), particularly in situations where inhalation anaesthesia is unavailable. Nevertheless, prolonged administration may result in dose-dependent cardiorespiratory depression and greater neonatal exposure when used throughout the surgical procedure. Conversely, inhalation anaesthesia with isoflurane provides excellent control over anaesthetic depth, minimal hepatic metabolism and rapid elimination through pulmonary exhalation, facilitating faster maternal recovery after surgery. Propofol induction followed by isoflurane maintenance has therefore become a commonly recommended protocol for canine caesarean section, although the requirement for specialised anaesthetic equipment may limit its routine use in many veterinary hospitals.

Evaluation of neonatal viability is an important component of assessing the safety of anaesthetic protocols. The modified APGAR scoring system has been widely adopted in veterinary neonatology as a rapid clinical method for assessing neonatal adaptation immediately after birth. The scoring system evaluates mucous membrane colour, heart rate, respiratory effort, reflex irritability, mobility, suckling reflex and vocalisation, enabling early identification of puppies requiring immediate resuscitation. In addition to clinical assessment, umbilical blood lactate concentration has emerged as a reliable indicator of intrapartum hypoxia and metabolic stress. Elevated lactate concentrations are associated with reduced tissue perfusion, anaerobic metabolism and poorer neonatal outcome. Combined assessment of APGAR score and umbilical blood lactate therefore provides a comprehensive evaluation of neonatal vitality following caesarean section.

Although several studies have evaluated individual anaesthetic agents used during canine caesarean section, comparative information regarding maternal recovery, neonatal vitality and metabolic status following propofol total intravenous anaesthesia and propofol–isoflurane anaesthesia remains limited under clinical conditions. Furthermore, information regarding postoperative maternal appetite, onset of lactation and early neonatal growth under these anaesthetic protocols is scarce. Such data are clinically important for selecting anaesthetic techniques that maximise neonatal survival without compromising maternal safety.

Therefore, the present study was undertaken to compare propofol total intravenous anaesthesia and propofol induction followed by isoflurane maintenance in bitches undergoing emergency caesarean section. The study evaluated maternal clinical and physiological responses, postoperative recovery, neonatal APGAR score, umbilical blood lactate concentration, neonatal body

weight and early maternal performance in order to identify the anaesthetic protocol that provides superior maternal and neonatal outcomes.

Materials and Methods

Animals and Experimental Design

The present investigation was conducted on eighteen pregnant bitches presented to the Veterinary Clinical Complex, Rajendranagar, and Veterinary Hospitals at Narayanaguda and Bhoiguda, Hyderabad, with a history of normal parturition or dystocia. The study was carried out after obtaining informed consent from the owners, and all procedures were performed following standard clinical and ethical guidelines for veterinary practice.

Twelve bitches diagnosed with dystocia and requiring emergency caesarean section were enrolled in the study. Animals were randomly allocated into two equal treatment groups (n = 6 each). Group I received total intravenous anaesthesia (TIVA) using propofol for both induction and maintenance, whereas Group II received propofol for induction followed by isoflurane for maintenance of anaesthesia.

Six healthy bitches undergoing spontaneous whelping served as the control group for comparison of neonatal parameters. The study included animals of different breeds, ages, body weights and parities presented near full-term gestation.

Clinical Evaluation

A detailed reproductive history was obtained from each animal, including age, parity, gestational duration, previous reproductive disorders, onset and progression of labour, duration of dystocia, vaginal discharge and the number of puppies delivered before presentation. General clinical examination included assessment of rectal temperature, heart rate, respiratory rate, pulse rate, capillary refill time, mucous membrane colour and body weight.

Obstetrical examination was performed by digital vaginal palpation to evaluate cervical dilatation, foetal presentation, position and posture, and to identify abnormalities of the birth canal. Abdominal radiography was carried out whenever necessary to determine foetal number, position and skeletal maturity.

Ultrasonographic Examination

All bitches underwent ultrasonographic evaluation using a 5.0 MHz multifrequency convex transducer (Mindray Ultrasound System). After clipping and aseptic preparation of the ventral abdomen, ultrasonography was performed with the animal in dorsal or lateral recumbency.

Foetal biparietal diameter (BPD) was measured to estimate gestational age using the equation:

Gestational age (days) = 20 + (15 × head diameter).

Foetal viability was assessed by observing foetal movements and measuring foetal heart rate using pulsed-wave Doppler ultrasonography. Foetuses with heart rates below 180 beats/min were considered distressed, whereas heart rates between 180 and 220 beats/min indicated moderate viability and values above 220 beats/min were considered normal.

Medical Management of Dystocia

Cases diagnosed with primary uterine inertia were initially managed medically. Intravenous dextrose (25%; 1 g/kg) was administered, followed by slow intravenous administration of 10% calcium gluconate (0.2 mL/kg; maximum 10 mL). Oxytocin (5–20 IU; 1.1–2.2 IU/kg, IM or SC) was administered 15 minutes later. If no puppy was delivered within 30 minutes, oxytocin administration was repeated at 30-minute intervals up to a maximum of three doses. Gentle obstetrical manipulation and traction were attempted whenever indicated. Animals failing to respond to medical treatment underwent emergency caesarean section.

Anaesthetic Protocol

All animals scheduled for caesarean section were premedicated with glycopyrrolate (0.01 mg/kg, IM) and butorphanol (0.02 mg/kg, IM) approximately 10 minutes before induction. Anaesthesia was induced with propofol (5 mg/kg, IV) administered to effect, followed by endotracheal intubation and oxygen supplementation.

In Group I, anaesthesia was maintained using continuous intravenous infusion of propofol (0.4 mg/kg/min) throughout the surgical procedure. In Group II, anaesthesia was maintained with isoflurane delivered in

100% oxygen using a rebreathing anaesthesia system. Isoflurane concentration was initially maintained at approximately 3% and subsequently reduced to 1.5% according to the depth of anaesthesia and physiological response of the animal.

Surgical Procedure

Following routine aseptic preparation of the ventral abdomen, a standard ventral midline laparotomy was performed. The gravid uterus was gently exteriorised and protected with sterile drapes. A longitudinal incision was made on the uterine body, and puppies were delivered sequentially from both uterine horns with minimal manipulation. Neonates were immediately handed over to an assistant for airway clearance and neonatal resuscitation. The uterus was closed using a two-layer inverting suture pattern with absorbable suture material. Routine closure of the abdominal wall and skin was completed using standard surgical techniques. Postoperative management included intravenous fluids, antimicrobial therapy (amoxicillin–sulbactam), meloxicam for analgesia, and routine wound care until complete recovery.

Maternal Evaluation

The following maternal variables were recorded and evaluated during the study: the time required for induction of anaesthesia, the interval between induction of anaesthesia and delivery of the first puppy, the total duration of surgery, the recovery time following discontinuation of anaesthesia, and the degree of muscle relaxation achieved throughout the surgical procedure. These parameters were assessed to compare the efficacy and safety of the anaesthetic protocols with respect to maternal performance during emergency caesarean section.

Physiological variables, including respiratory rate, heart rate, pulse rate, rectal temperature, capillary refill time and mucous membrane colour, were recorded before induction, at 30 minutes after induction and at the completion of surgery. Postoperative appetite, onset of lactation and changes in maternal body weight were also monitored.

Neonatal Evaluation

Immediately after delivery, foetal membranes and airway secretions were removed and puppies were dried using sterile towels. Neonates showing respiratory depression received tactile stimulation, oxygen supplementation and additional resuscitative measures as required.

Neonatal viability was assessed using the modified canine APGAR scoring system immediately after birth and subsequently at 30 and 60 minutes postpartum. The scoring system included evaluation of mucous membrane colour, heart rate, respiratory effort, reflex irritability, mobility, suckling reflex and vocalisation.

Umbilical cord blood was collected immediately after delivery using heparinised syringes, and blood lactate concentration was determined within 10 minutes using a portable lactate analyser (LactoSpark®). Neonatal body weight was recorded at birth and again on the tenth day after birth to evaluate early growth. Rectal temperature was monitored during the immediate neonatal period.

Statistical Analysis

Data obtained during the study were expressed as Mean ± Standard Error (SE). Statistical analysis was performed using appropriate software. Differences between treatment groups were analysed using one-way analysis of variance (ANOVA), followed by suitable comparison wherever applicable. Differences were considered statistically significant at $P < 0.05$.

Results and Discussion

A total of 18 near-term bitches were included in the study, comprising six bitches that underwent spontaneous whelping (Control), six dystocia cases managed by emergency caesarean section under propofol total intravenous anaesthesia (Group I), and six dystocia cases managed under propofol induction followed by isoflurane maintenance (Group II). Sixty-one live puppies delivered from these bitches were evaluated for neonatal viability. Maternal clinical characteristics, physiological responses, surgical parameters and neonatal variables were recorded and analysed.

Signalment of Experimental Animals

The age, body weight and gestational age of the bitches included in the study were comparable among the three groups ($P>0.05$), indicating a uniform distribution of experimental animals. The overall mean age of the

animals was 3.92 ± 0.48 years, with body weight ranging from 9 to 50 kg and gestational age averaging 62.29 ± 0.45 days. Median parity varied between the first and fifth parity, with no significant difference observed among the experimental groups (Table 1).

Ultrasonographic Findings

Preoperative ultrasonographic examination confirmed foetal viability in all study animals. Mean foetal biparietal diameter measured 2.78 ± 0.06 cm and did not differ significantly among the groups (P>0.05). Similarly, foetal heart rate remained within the normal physiological range in all groups, with an overall mean value of 205.2 ± 4.3 beats/min. No statistically significant variation was observed between treatment groups for either parameter (Table 2).

Anaesthetic and Surgical Parameters

Mean induction time following intravenous propofol administration was 3.00 ± 0.37 min in Group I and 2.67 ± 0.33 min in Group II, with no significant difference between the groups (P>0.05). Likewise, the interval between induction of anaesthesia and delivery of the first puppy remained comparable, averaging 16.00 ± 1.41 min in Group I and 15.83 ± 0.60 min in Group II.The duration of surgery averaged 77.30 ± 3.40 min in Group I and 72.50 ± 3.36 min in Group II. Recovery time following completion of surgery was 18.60 ± 1.90 min in Group I and 14.20 ± 1.50 min in Group II. None of these variables differed significantly between the anaesthetic protocols (P>0.05).Muscle relaxation was graded as good in the propofol TIVA group and excellent in the propofol–isoflurane group, providing satisfactory surgical conditions in both groups (Table 3).

Maternal Physiological Responses

Maternal physiological variables were monitored throughout anaesthesia to evaluate the effects of both anaesthetic protocols. Respiratory rate was significantly higher (P<0.05) in Group I than in Group II at induction, 30 min after induction and at the completion of surgery. Mean respiratory rate ranged from 27.80 to 29.30 breaths/min in Group I, whereas values ranged from 13.85 to 15.60 breaths/min in Group II.

Heart rate and pulse rate remained within physiological limits throughout the observation period in both groups. Statistical analysis revealed no significant differences between the two anaesthetic protocols (P>0.05). Rectal temperature gradually decreased during surgery in both groups, reflecting the expected hypothermic effect of general anaesthesia. Although temperature declined significantly over time within each group, no significant difference was observed between the treatment groups.

Capillary refill time showed a mild increase during anaesthesia in both groups but remained within the normal clinical range. Conjunctival mucous membranes appeared mildly congested throughout the procedure in both groups, and no clinically relevant differences were observed between the anaesthetic protocols (Table 4).

Maternal Recovery Following Surgery

Postoperative recovery was uneventful in all animals. Appetite returned earlier in bitches maintained under propofol–isoflurane anaesthesia than in those maintained under propofol TIVA. Similarly, lactation commenced earlier in Group II, whereas delayed milk secretion was observed more frequently in Group I. A mild reduction in maternal body weight was recorded following parturition in both treatment groups, without significant differences between them.

Neonatal APGAR Score

Neonatal viability was assessed using the modified APGAR scoring system at birth and during the first hour after delivery.

Puppies born by spontaneous whelping consistently exhibited the highest APGAR scores throughout the observation period. Among puppies delivered by caesarean section, significantly higher APGAR scores (P<0.05) were recorded in Group II than in Group I at all evaluation intervals. Progressive improvement in APGAR score was observed during the first 60 min after birth in both caesarean groups; however, puppies delivered under propofol–isoflurane anaesthesia recovered more rapidly than those delivered under propofol TIVA.

Umbilical Blood Lactate Concentration

Umbilical blood lactate concentration differed significantly among the study groups (P<0.05). The lowest lactate concentration was observed in the spontaneous whelping group (4.2 ± 0.5 mmol/L), followed by Group II (6.7 ± 0.7 mmol/L), whereas

puppies delivered under propofol TIVA exhibited the highest concentration (11.8 ± 1.6 mmol/L). These findings indicated greater metabolic stress in neonates delivered under total intravenous anaesthesia (Table 5).

Neonatal Growth

Mean birth weight did not differ significantly among the study groups (P>0.05). Similarly, body weight recorded on Day 10 remained comparable between treatment groups, although puppies born to bitches maintained under propofol–isoflurane anaesthesia showed numerically greater weight gain than those delivered under propofol TIVA.

The present investigation compared the influence of propofol total intravenous anaesthesia (TIVA) and propofol induction followed by isoflurane maintenance on maternal recovery and neonatal viability in bitches undergoing emergency caesarean section for dystocia. Successful anaesthetic management during canine caesarean section requires maintenance of maternal cardiovascular stability while minimizing placental transfer of anaesthetic agents and their depressive effects on neonates. The findings of the present study demonstrated that both protocols provided satisfactory surgical anaesthesia; however, propofol–isoflurane anaesthesia resulted in superior neonatal viability and improved postoperative maternal performance.

The absence of significant differences in age, body weight, parity and gestational age among the experimental groups indicated that the animals were uniformly distributed before initiation of treatment. Similar baseline characteristics minimise biological variation and permit reliable comparison of maternal and neonatal responses between anaesthetic protocols. These observations agree with previous clinical studies on canine caesarean section in which comparable signalment among treatment groups was considered essential for unbiased evaluation of anaesthetic outcomes.

Foetal biparietal diameter and foetal heart rate measured before surgery remained within normal physiological limits and did not differ significantly among the groups. Ultrasonographic assessment of these variables confirmed comparable foetal maturity and viability before intervention. Biparietal diameter remains one of the most reliable ultrasonographic measurements for estimating gestational age in late pregnancy, while foetal heart rate is widely accepted as a sensitive indicator of foetal well-being. Similar observations have been reported by Beccaglia and Luvoni (2006), Lopate (2008) and Nyland and Mattoon (2015), who demonstrated the usefulness of ultrasonography for assessment of foetal maturity and distress in bitches.

Induction time, interval between induction and delivery of the first puppy, duration of surgery and recovery time were comparable between the two anaesthetic protocols. Since propofol was used for induction in both groups, rapid loss of consciousness and successful endotracheal intubation were achieved irrespective of the maintenance protocol. Similar induction time and interval between the induction and delivery of the first puppy were reported by Shravya (2017), Duke novakovski *et al.,* (2016) and Grimm *et al.,* (2015). The slightly shorter recovery observed in the propofol–isoflurane group may be attributed to the low blood-gas solubility of isoflurane, which allows rapid elimination through the lungs following discontinuation of anaesthesia. Previous investigations have similarly reported rapid induction with propofol and smooth recovery following isoflurane maintenance in canine patients undergoing caesarean section.

Muscle relaxation was consistently superior in bitches maintained with isoflurane. Adequate muscle relaxation facilitates uterine manipulation, reduces tissue trauma and improves surgical efficiency. Inhalation anaesthetic agents produce dose-dependent skeletal muscle relaxation through central nervous system depression, thereby providing more favourable operating conditions than intravenous maintenance alone. Although propofol also provides satisfactory muscle relaxation, maintenance with isoflurane appears to offer improved surgical conditions, particularly during prolonged abdominal procedures.

Enhanced muscle relaxation under isoflurane has been attributed to its vasodilatory effects and improved tissue perfusion, as reported by Ramankutty (2008). However, Short and Bufalari (1999).

Respiratory rate was significantly lower in the propofol–isoflurane group throughout anaesthesia. This finding reflects the well-recognised respiratory depressant effect of inhalation anaesthetic agents, which reduce respiratory frequency while maintaining adequate oxygenation under controlled anaesthesia.

Table.1 Detailed signalment of the dystocia bitches subjected to dystocia

Parameters	Control group (n =6)	Group I (n = 6)	Group II (n = 6)
Age of bitches (Years)	3.58 ± 0.60[a]	4.13 ± 0.71[a]	3.71 ± 0.67[a]
Body weight of bitches (Kg)	15.12 ± 2.10[a]	19.48 ± 6.71[a]	13.87 ± 1.57[a]
Gestational age of bitches (Days)	62.38 ± 0.62[a]	62.21 ± 0.71[a]	62.29 ± 0.68[a]

There is no significant difference in the signalment of the dystocia bitches which are subjected to dystocia

Table.2 Details of ultrasonographic examination of the dam

Group	Number of bitches (n)	Heart rate (bpm)	Biparietal diameter (cm)
Control	6	205.2 ±7.10[a]	2.81 ± 0.06 cm [a]
I	6	203.8 ± 6.91 [a]	2.74 ± 0.07 cm [a]
II	6	206.7 ± 8.2 [a]	2.79± 0.05 [a]

There is no significant difference in the details of the ultrasonographic examination of the dam.

Table.3 Clinical evaluation of the Bitch

Clinical parameters	Group I	Group II
Induction time (min)	3.00 ± 0.37[a] mins	2.67 ± 0.33[a] mins
Interval between induction and pup removal (min)	16 ± 1.41[a] mins	15.83 ± 0.60[a] mins
Total surgery time (min)	77.3 ± 3.40[a] mins	72.5 ± 3.36[a] mins
Recovery time (min)	18.6 ± 1.9[a] mins	14.2 ± 1.5[a] mins

There is no significant difference in the clinical evaluation of the bitches.

Table.4 Physiological parameters of the bitch

Physiological parameters	Group	Induction	At 30 mins after the induction	After the surgery
Rate of respiration (BPM)	I	28.40 ± 4.10[a]	27.80 ± 3.95[a]	29.30 ± 3.73 [a]
	II	15.60 ± 1.20[b]	14.70 ± 1.05[b]	13.85 ± 0.95 [b]
Heart rate (bpm)	I	105.20 ± 6.10[a]	107.00 ± 5.85[a]	115.80 ± 11.90 [a]
	II	128.90 ± 10.80[a]	115.50 ± 10.20[a]	120.30 ± 10.45[a]
Pulse rate (per min)	I	105.20 ± 6.10[a]	107.00 ± 5.85[a]	115.80 ± 11.90 [a]
	II	129.40 ± 9.95[a]	124.80 ± 10.40[a]	120.30 ± 10.85[a]
Temperature (°F)	I	99.62 ± 1.05[a]	98.40 ± 0.82[a]	99.72 ± 0.56[a]
	II	97.18 ± 0.50[a]	98.85 ± 0.82[a]	97.70 ± 0.52[a]
Capillary refill time sec)	I	0.071 ± 0.05[a]	0.83 ± 0.60[a]	0.92 ± 0.14[a]
	II	0.088 ± 0.06[a]	0.85 ± 0.07[a]	0.90 ± 0.15[a]
Conjunctival Mucous Membrane (CMM)	I	Congested[a]	Congested[a]	Congested[a]
	II	Congested[a]	Congested[a]	Congested[a]

The Values with different superscripts a,b within the row are significantly different ($p<0.05$).

Table.5 Association of Mean Apgar score off neonate at birth, 15 mins, 30 mins, 60 mins under different anesthetic protocols

Group	No of bitches (n)	No of neonates	Apgar score at birth	Apgar score at 15 mins	Apgar score at 30 mins	APGAR score at 45 mins	Apgar score at 60 mins	Over all mean Apgar score
Control	6	20	8.5 ± 0.5^{a}	10.5 ± 0.4^{a}	11.9 ± 0.4^{a}	12.0 ± 0.4^{a}	12.4 ± 0.3^{a}	10.83 ± 0.3^{a}
I	6	23	2.8 ± 0.4^{c}	4.4 ± 0.4^{c}	6.8 ± 0.6^{c}	9.6 ± 0.5^{b}	11.6 ± 0.4^{b}	6.40 ± 0.4^{b}
II	6	18	3.7 ± 0.4^{bc}	6.9 ± 0.5^{b}	8.2 ± 0.5^{b}	10.6 ± 0.4^{b}	12.0 ± 0.7^{a}	7.70 ± 0.4^{b}

The Values with different superscripts a, b, c within the row are significantly different ($p<0.05$)

Table.5 Umbilical blood lactate

Group	No of neonates	Umbilical blood lactate (mmol/L)
Control group	20	4.2 ± 0.5^{a}
I	23	11.8 ± 1.6^{b}
II	18	6.7 ± 0.7^{a}

The values with the different superscripts differ significantly ($p < 0.05$).

Table.6 Day 1 and day 10 body weight of Neonates

GROUPS	DAY 1 BODY WEIGHT (gm)	DAY 10 BODY WEIGHT (gm)
CONTROL	278.80 ± 13.90	575.40 ± 26.80
Group I	272.50 ± 14.40	545.00 ± 28.80
Group II	274.92 ± 15.31^{aA}	$605.83\pm30.62\ g^{aB}$

There is no significant difference in bodyweight of the neonates on day 1 and day 10

Fig.1 Bitch with the history of dystocia

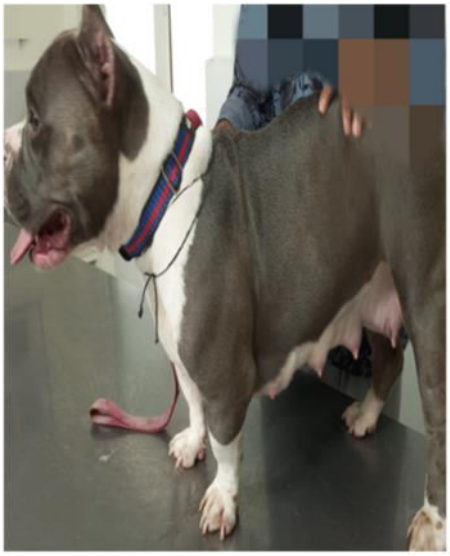

Fig.2 Estimation of foetal age by Mindray Ultrasonography

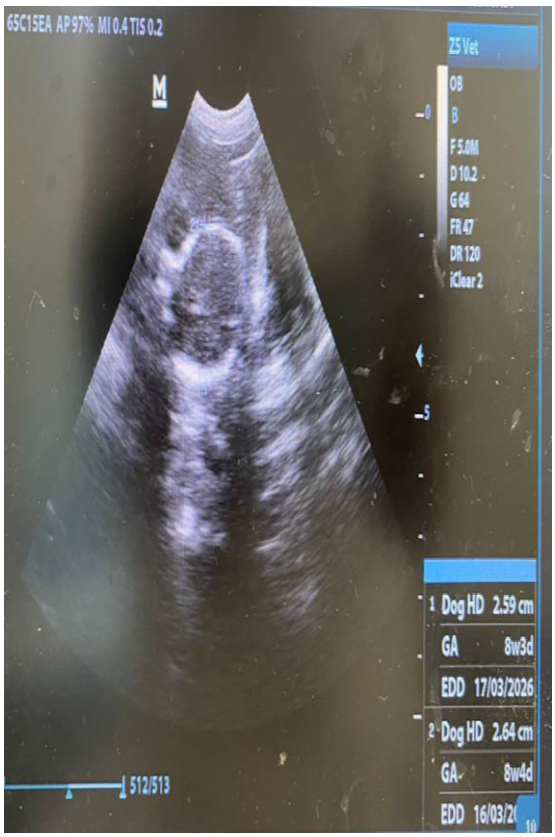

Fig.3 Exteriorization of the uterus

Fig.4 Removal of foetus and umbilicus clamping

Fig.5 Pup extracted from the bitch

Fig.6 Pup showing righting reflex in neonatal incubator chamber

Fig.7 Umbilical blood lactate measurement by using Lactospark device

Fig.8 Body weight of pups after 10 days

Despite this reduction, heart rate, pulse rate and capillary refill time remained within acceptable physiological limits in both treatment groups, indicating that cardiovascular stability was maintained throughout the surgical procedure. Progressive reduction in rectal temperature observed during surgery was expected because general anaesthesia suppresses thermoregulatory mechanisms and increases peripheral heat loss. Similar

observations have been reported by Grimm *et al.,* (2015), Robertson and Gogolski, 2020. However, Tranquilli *et al.,* (2013) and Duke -Novakovski *et al.,* (2016) have emphasized that heart rate alone may not fully reflect the cardiovascular performance, as multiple perioperative factors influence the haemodynamic responses, such as packed cell volume, haemoglobin and red blood cell count.

One of the most important findings of the present study was the improvement in neonatal vitality associated with propofol induction followed by isoflurane maintenance. Puppies delivered under this protocol consistently achieved higher APGAR scores during the first hour after birth than puppies delivered under propofol TIVA. These findings suggest more rapid neonatal adaptation to extrauterine life and reduced anaesthetic depression. APGAR scoring remains a practical clinical method for early identification of compromised neonates and provides valuable guidance regarding the need for resuscitative intervention. The superior APGAR scores observed in the present investigation are consistent with reports indicating improved neonatal responsiveness following balanced anaesthetic protocols that minimise prolonged exposure to intravenous agents. The significantly higher overall APGAR scores observed in Group II compared to Group I support the findings of Veronesi *et al.,* (2022) and Robertson and Gogolski (2020), indicating that inhalant-based maintenance anaesthesia offers a clinical advantage in improving neonatal vitality following caesarean section.

Umbilical blood lactate concentration provided additional evidence regarding neonatal metabolic status. Puppies delivered under propofol TIVA exhibited significantly higher lactate concentrations than those delivered under propofol–isoflurane anaesthesia and spontaneous whelping. Increased lactate concentration reflects anaerobic metabolism secondary to reduced tissue perfusion and intrapartum hypoxia. Lower lactate values recorded in Group II indicate better oxygen delivery and reduced metabolic stress during delivery. Assessment of umbilical lactate together with APGAR scoring therefore offers a comprehensive evaluation of neonatal viability and may improve early prognostic assessment following canine caesarean section. Similar trends have been reported by Veronesi *et al.,* (2009), Jayakumar *et al.,* (2016), and Shravya (2017).

Maternal recovery following surgery was satisfactory in both treatment groups; however, earlier return of appetite and more rapid onset of lactation were observed in bitches maintained with isoflurane. Early maternal recovery is clinically important because successful nursing and colostrum intake during the immediate postpartum period contribute substantially to neonatal survival. Faster elimination of isoflurane following cessation of anaesthesia probably facilitated earlier restoration of normal maternal behaviour and nursing activity. Although neonatal body weight at birth and during the early postnatal period did not differ significantly between groups, puppies delivered under propofol–isoflurane anaesthesia demonstrated a tendency towards improved early growth, possibly reflecting earlier initiation of suckling and better maternal care.

Overall, the findings of the present study indicate that both anaesthetic protocols are suitable for canine caesarean section; however, propofol induction followed by isoflurane maintenance offers important clinical advantages by improving neonatal vitality without compromising maternal physiological stability. Incorporation of objective neonatal assessment tools such as APGAR scoring and umbilical blood lactate estimation provides valuable information for evaluating anaesthetic safety and may assist clinicians in selecting protocols that optimise maternal and neonatal outcomes during emergency caesarean section.

In conclusion, the present study demonstrated that both propofol total intravenous anaesthesia and propofol induction followed by isoflurane maintenance provided satisfactory anaesthesia for emergency caesarean section in bitches. Maternal clinical variables, including induction time, interval between induction and delivery of the first puppy, duration of surgery and recovery time, were comparable between the two anaesthetic protocols. However, maintenance of anaesthesia with isoflurane resulted in superior muscle relaxation and earlier postoperative recovery of maternal functions, including appetite and lactation. Neonatal assessment revealed that puppies delivered under propofol–isoflurane anaesthesia exhibited significantly higher APGAR scores and lower umbilical blood lactate concentrations than those delivered under propofol total intravenous anaesthesia, indicating reduced neonatal depression and improved physiological adaptation after birth. Although neonatal body weight did not differ significantly between the treatment groups, the overall neonatal vitality and maternal performance favoured the propofol–isoflurane protocol. The findings of the present investigation

suggest that propofol induction followed by isoflurane maintenance is a safer and more effective anaesthetic protocol for canine emergency caesarean section, as it provides adequate maternal anaesthesia while improving neonatal viability and reducing metabolic stress. Furthermore, the combined use of modified APGAR scoring and umbilical blood lactate estimation proved to be a practical and reliable approach for the early assessment of neonatal well-being and may assist clinicians in making timely decisions regarding neonatal resuscitation and postoperative management. These observations support the routine clinical use of balanced inhalational anaesthesia to optimise maternal and neonatal outcomes in bitches undergoing emergency caesarean section.

Author Contributions

V. Pranay Vishal: Investigation, formal analysis, writing—original draft. K. Ramchandra Reddy: Validation, methodology, writing—reviewing. E. Sunil Anand Kumar:—Formal analysis, writing—review and editing. M. Sravanti: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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